

Using MISSE-FF to Determine the Effect of the Space Environment on Advanced Thermal Protection Coatings, Phase I

Completed Technology Project (2018 - 2019)



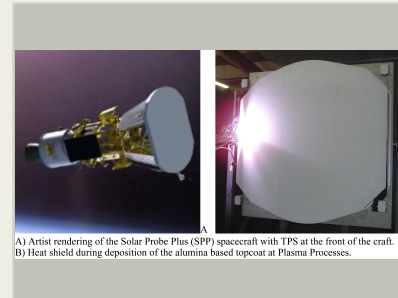
Project Introduction

Ceramic-based Thermal Protection Systems (TPS) are ideally suited for protecting spacecraft and crew from high temperature propellant gases and heating from solar radiation. In addition, ceramic based Thermal Barrier Coatings (TBC) are being applied to rocket engine components such as combustion chambers, injector face plates, and nozzle extensions to allow higher temperature propellants to be used, which results in increased performance. Similar TPS/TBC applications can be proposed for space habitat structures, CubeSats, and satellites for thermal management against solar radiation heating. All of these systems rely on the low thermal conductivity and emissive properties of the ceramic topcoat to minimize heat transfer. However because of the thermal expansion mismatch between the ceramic topcoat and underlying metallic structure, special care must be taken during joining. Geo-Plasma has developed innovative Additive Manufacturing (AM) techniques that allow the gradual transition from a metallic substrate to the low thermal conductivity ceramic topcoat. This graded composition allows the joining of materials with large thermal expansion mismatch by eliminating the concentration of thermal induced stresses at a planar bond joint. To optimize the use of these materials for spacecrafts such as the Orion crew capsule, Exploration Upper Stage (EUS), space habitats, satellites, and CubeSats for extended duration missions, the effect of the space environment on these advanced coating systems must be determined. Therefore, Geo-Plasma proposes to develop advanced thermal protection coatings using these advanced AM methods, and then use the MISSE-FF to test the coatings in Low Earth Orbit (LEO).

Anticipated Benefits

Potential NASA applications for this technology developed through Phase II include protection of humans and electronics in aerospace transportation vehicles, space transportation vehicles, large space structures, such as space stations, orbiters, landing vehicles, rovers, habitats, and nuclear propulsion.

Potential non-NASA customers include SpaceX, Boeing, Orbital-ATK, Lockheed, Bigelow Aerospace and other aerospace companies. In addition to aerospace markets, this technology can be leveraged across broader government and commercial applications for power generation, medical, electronics, and corrosion/thermal protection coatings.



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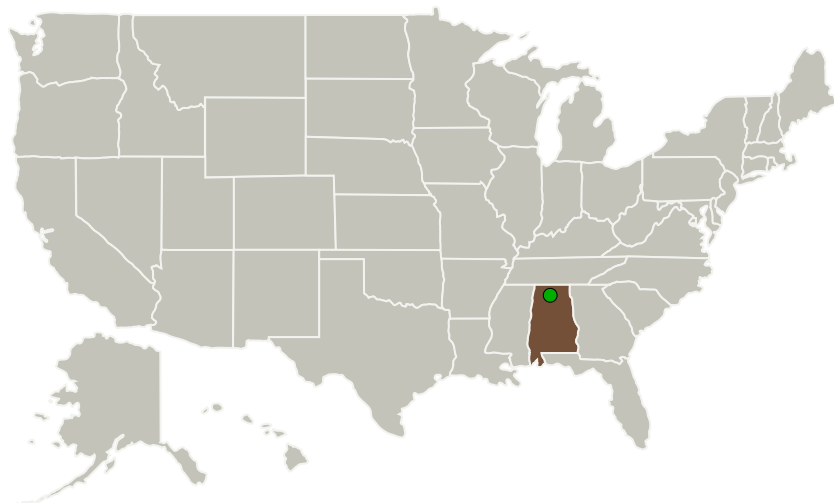
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Geoplasma, LLC	Lead Organization	Industry	Huntsville, Alabama
● Marshall Space Flight Center (MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations

Alabama

Project Transitions

**July 2018:** Project Start**February 2019:** Closed out**Closeout Documentation:**

- Final Summary Chart(<https://techport.nasa.gov/file/141354>)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Geoplasma, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

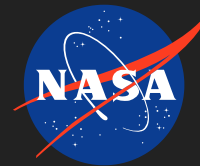
John Scott S O'dell

Co-Investigator:

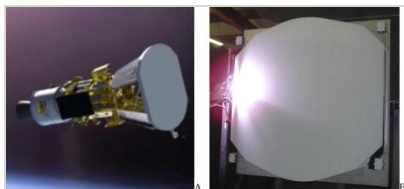
John Scott O'dell

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Images

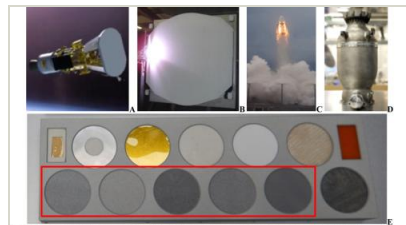


A) Artist rendering of the Solar Probe Plus (SPP) spacecraft with TPS at the front of the craft.
B) Heat shield during deposition of the alumina based topcoat at Plasma Processes.

Briefing Chart Image

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(<https://techport.nasa.gov/image/133709>)



A) Artist rendering of the Parker Solar Probe (PSP) spacecraft with TPS at the front of the craft.
B) Heat shield during deposition of the TPS topcoat at Plasma Processes.
C) SpaceX Crew Dragon capsule from NASA Commercial Crew Program (CCP) during launch abort test.
D) Crew Dragon SuperDraco engine that is used during launch abort. These engines are currently being coated with TPS/TBC by Plasma Processes.
E) Phase I TPS/TBC coatings on Inconel substrates loaded in carrier for exposure to the space environment on MISSE-11.

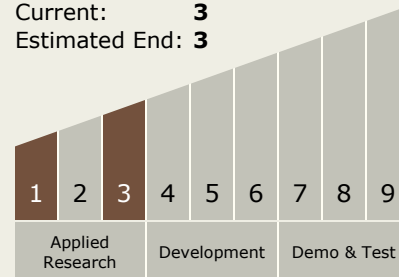
Final Summary Chart Image

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(<https://techport.nasa.gov/image/135536>)

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - TX12.1 Materials
 - TX12.1.5 Coatings

Target Destinations

Earth, The Moon, Mars